RISK-BASED ANALYSIS OF BRIDGE SCOUR PREDICTION WITH LIVE BED CONDITIONS

First year workout

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Outline

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1. Motivation

Schoharie Creek bridge, NY, USA, 1987

- Flood warning action plan
- Post-flood inspections
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Collapsed due to bridge scour at the foundations after a record rainfall.

Improvement of hydraulic and scour evaluations through:

- Post-flood inspections
- Flood warning action plan
1. Motivation

PORTUGAL

1983: Partial collapse of the Penacova bridge

1994: Structural failure of Gafanha bridge, in Aveiro

2001: Displacement of the bridge abutment of bridge over Sorraia river causing its failure

The most recent and hazardous case of scour, registered in Portugal, occurred in 2001 with the collapse of the Hintze-Ribeiro bridge, causing 59 casualties.
….from a brief literature review

**Flood, Scour and other hydraulic events are the most common causes of bridge collapses!**

*Johnson et al. (2015)* developed a risk/reliability-based methodology to be used in calculating bridge pier, linking scour estimates to a probability; always using a 100-year return period for the hydrologic event.

*However,*

*Flint et al. (2017)* showed that scour-induced collapses were associated with return periods lower than 100 years.

*Thus,*

…there is still a lot of improvements to make in this field, particularly in **placing most hydrologic and hydraulic facets** of bridge design at similar levels of reliability as structural and geotechnical facets.
2. Objectives

Develop a **risk-based method** for **predicting** the likely **bridge scour** under **live bed** conditions

- **Case studies**
  - Establish relationships between flow duration curves and flood hydrographs probability
  - Application to real Portuguese bridges

- **CFD modelling**
  - Evaluate the prediction of scouring process by readily available CFD tools

- **Laboratory work**
  - Extract functional relations between flood scenarios and scouring effects
  - Data for calibration and validation
3. Approach and Methodologies

Case studies:

Typical bridge piers geometry - XIX century

Streamflow data – typically a sequence of flow peaks [2,3,4]

Bathymetry and granulometry – site specific

Laboratory work:

Column bridge pier

Hydrographs of different shapes and durations under clear water and live bed scour conditions [5]

Sand characteristics: uniform sand bed ($\sigma_d = 1.4$, $D_{50} = 0.86$ mm)
4. Work Done

A) Completion of the academic curricular courses:
   • Uncertainty / Risk and Reliability courses: 10 credits
   • Courses units at FEUP: 10 credits

B) Compilation of the literature review:
   • Bridge scour processes
   • Uncertainty and reliability methodologies in bridge scour estimation
   • Research techniques for both laboratory and numerical environments

C) Collection of real cases data:
   • Contacts with Infrastructures of Portugal (IP)
   • Bathymetry, granulometry and streamflow data
5. Work in Progress (1/2)

D) **Laboratory** work:

- Adaptation of the tilting flume (CIV), at Fluvial Hydraulics Pavilion of LNEC
- Trial runs of experimental methodologies

**Experiment 1**

Flume at LNEC (40 m long and 2 m wide)

Scour hole at pier vicinity (L = 14 cm; ds = 23 cm - 3 days)
5. Work in Progress (2/2)

- Analysis of first experimental results

Point-wise measurements

3D characterization of the scour hole
6. Future Developments

E) Case studies:
- Selection of real case studies
- Collection of historical records of hydrologic and hydraulic data
- Statistical and uncertainty analysis of hydrologic and hydraulic data

F) Experiments:
- Campaign of laboratory experiments
- Scour morphology vs flow conditions vs return periods
- Submission of a conference paper, describing goals research, experimental facility and respective results

G) Numerical modelling:
- Preparation of the numerical setup according with the experimental conditions and calibrated using experimental results
- Application/Improvement of flow and sediment transport models

H) Risk analysis:
- Definition of a probability failure criterion based on Pf
- Derivation of empirical cumulative distribution functions of exceedance of conventional bridge design criteria
- Establishment of the risk failure for such structures

I) Publishing:
- Conference and journal papers
- PhD thesis writing

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7. Main references


Thank you!

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